

Flower-visiting clearwing moths in the Oki Islands, Japan

Shinji SUGIURA^{1)*}, Kota SAKAGAMI¹⁾ and Masakazu HAYASHI²⁾

¹⁾ Graduate School of Agricultural Science, Kobe University, Rokkodai, Nada, Kobe, 657-8501 Japan

²⁾ Hoshizaki Green Foundation, Izumo, Shimane, 691-0076 Japan

Abstract Adult clearwing moths (Lepidoptera: Sesiidae) are diurnal lepidopterans. Although many studies have investigated the flower-visiting behaviour of diurnal lepidopterans such as butterflies, few studies have reported the relationships between clearwing moths and flowers. In this study, we report the flower-visiting behaviour of three clearwing moth species in the Oki Islands in central Japan. On the island Nakanoshima, *Glossosphecia romanovi* (Leech) and *Macroscelisia japona* (Hampson) were observed visiting flowers of *Ligustrum lucidum* Aiton (Oleaceae) in early July 2018. On Nishinoshima, *G. romanovi* and *Synanthedon unocingulata* Bartel were observed visiting flowers of *Kalopanax septemlobus* (Thunb.) Koidz. (Araliaceae) in the same season. Although *Ma. japona* has been previously reported to visit the flowers of other plant species, to our knowledge, this is the first report of the flower-visiting behaviour of *G. romanovi* and *Sy. unocingulata*. This is also the first record of *G. romanovi* and *Sy. unocingulata* on the Oki Islands.

Key words flower-visiting behaviour, plant–insect relationships, pollinators, Sesiidae.

Introduction

Adult clearwing moths (Lepidoptera: Sesiidae) are well known to mimic wasps and bees (Scoble, 1992; Skowron Volponi *et al.*, 2018). All clearwing moth species are diurnal lepidopterans (Arita and Ikeda, 2000), and some have a functional proboscis to feed on water and/or nectar (Scoble, 1992). Many studies have investigated the flower-visiting behaviour of diurnal lepidopterans (i.e., butterflies; Kunte, 2007; Tiple *et al.*, 2009). However, few studies have reported the relationships between clearwing moths and flowers (Arita and Ikeda, 2000).

Japanese clearwing moths comprise 48 species in 10 genera (Jinbo, 2016). Although many are thought to visit flowers for nectar, the flower-visiting behaviour of more than half of these species remains undocumented (Arita and Ikeda, 2000). Therefore, accumulating flower-visiting records of Japanese clearwing moths would contribute to our understanding of the relationship between diurnal lepidopterans and flowering plants. In this study, we report the flower-visiting behaviour of three clearwing moth species in the Oki Islands of central Japan.

Table 1. Plant species observed in this study.

Plant family	Plant species	Study island	Flower visits by clearwing moths
Apiaceae	<i>Angelica japonica</i>	Dōgo, Nishinoshima, Nakanoshima	–
	<i>Dystaenia takeshimana</i>	Nakanoshima	–
	<i>Daucus carota</i>	Nishinoshima	–
Araliaceae	<i>Kalopanax septemlobus</i>	Dōgo, Nishinoshima, Nakanoshima	<i>Glossosphecia romanovi</i> , <i>Synanthedon unocingulata</i>
Asteraceae	<i>Erigeron annuus</i>	Dōgo, Nishinoshima, Nakanoshima	–
Clethraceae	<i>Clethra barbinervis</i>	Dōgo, Nishinoshima	–
Fabaceae	<i>Albizia julibrissin</i>	Dōgo, Nishinoshima, Nakanoshima	–
Oleaceae	<i>Ligustrum lucidum</i>	Nakanoshima	<i>G. romanovi</i> , <i>Macroscelisia japona</i>
Rutaceae	<i>Zanthoxylum ailanthoides</i>	Dōgo, Nishinoshima, Nakanoshima	–
Vitaceae	<i>Cayratia japonica</i>	Nishinoshima	–

*Corresponding author: sugiura.shinji@gmail.com

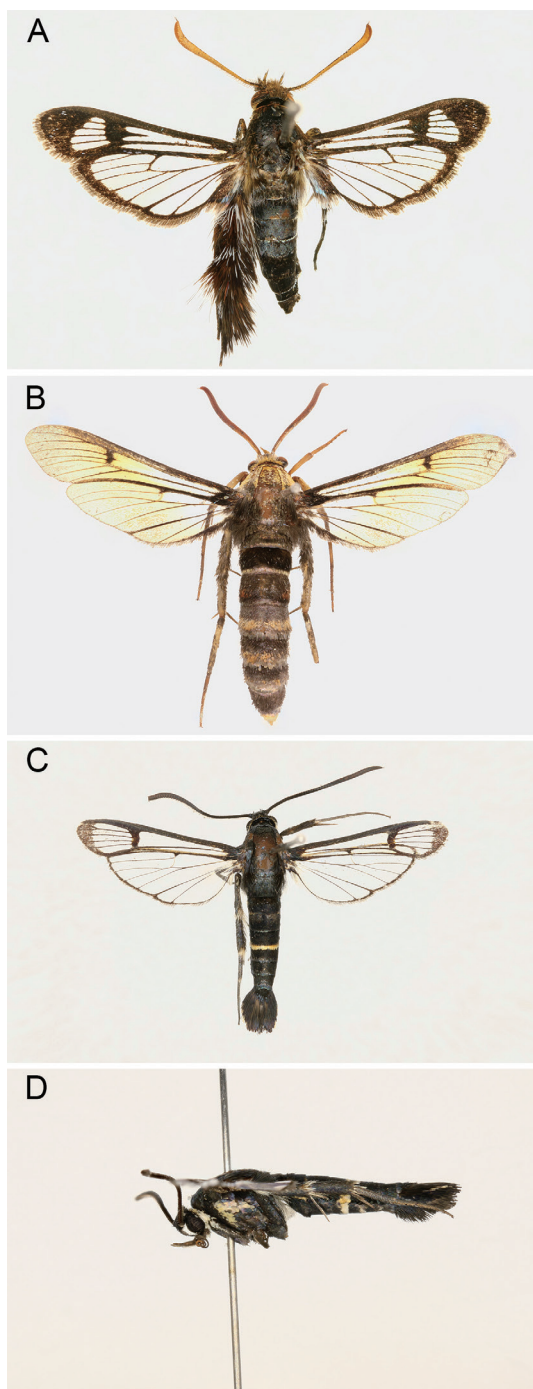


Fig. 1. Clearwing moths collected from flowers in the Oki Islands. (A) Female *Macroscelesia japona* collected from *Ligustrum lucidum* flowers. (B) Female *Glossosphecia romanovi* (Leech) collected from *Kalopanax septemlobus* flowers. (C–D) Male *Synanthedon unocingulata* collected from *K. septemlobus* flowers. *Synanthedon unocingulata* was identified based on the yellow band of its lateral thorax (D).

Materials and methods

The Oki Islands are continental islands ca. 40 km north of the Japanese main island, Honshu (Oki Islands Geopark Promotion Committee, 2013). The Oki Islands include four inhabited islands: Dōgo (241.6 km²), Nishinoshima (55.9 km²), Nakanoshima (32.4 km²), and Chiburijima (13.0 km²). The insect fauna of these islands and their ecological roles have recently been investigated (e.g., Hayashi *et al.*, 2012, 2013; Sugiura and Hayashi, 2018). In 2018, one of these authors (SS) observed and collected insects visiting the flowers of 10 plant species on Dōgo (6–8 July), Nishinoshima (8–10 July), and Nakanoshima (9 July) (Table 1). The weather was rainy and/or cloudy on 6–8 July, and sunny on 9–10 July. In this study region, the rainy season began on 5 June and ended on 8 July. An insect net (pole length: 1.2–8.0 m) was used to sample flower-visiting insects. The collected insects were killed with ethyl acetate and then brought to the laboratory. Clearwing moths were identified based on external morphology (Arita and Ikeda, 2000; Arita, 2013). The body length, forewing length, and proboscis length of each moth were measured using digital slide callipers. The right and left forewings were measured, and these values were then averaged.

Results and discussion

On Nakanoshima, a male *Glossosphecia romanovi* (Leech) and a female *Macroscelesia japona* (Hampson) were observed visiting flowers of *Ligustrum lucidum* Aiton (Oleaceae) (Table 2; Fig. 1A). On Nishinoshima, a female *G. romanovi* and a male *Synanthedon unocingulata* Bartel were observed visiting flowers of *Kalopanax septemlobus* (Thunb.) Koidz. (Araliaceae) (Table 2; Fig. 1 B–D). *Glossosphecia romanovi* were collected when they settled on inflorescences to sip nectar, and other species were collected while they hovered around the inflorescences. Because *Li. lucidum* and *K. septemlobus* flowers do not have floral tubes, their nectar is easily accessible to various insects, including beetles, hoverflies, and wasps.

Six clearwing moth species are known to inhabit the Oki Islands (Table 3; Kadowaki and Kishida, 1977; Mishima and Ohama, 2009; Hayashi *et al.*, 2012, 2013). Although *Ma. japona* has been previously collected from Nishinoshima (Hayashi *et al.*, 2013), this study is the first record of *G. romanovi* and *Sy. unocingulata* collection from the Oki Islands.

Table 2. Clearwing moths observed visiting flowers in this study.

Clearwing moth species	Sex	Length (mm)			Plant species visited by moths	Site	Time, date
		Proboscis	Forewing	Body			
<i>Glossospehia romanovi</i>	Male	5.2	20.1	25.1	<i>Ligustrum lucidum</i>	Saki (alt. 0 m) on Nakanoshima	12:00 on 9 July 2018
	Female	5.7	19.0	25.8	<i>Kalopanax septemlobus</i>	Uragou (alt. 100 m) on Nishinoshima	13:30 on 10 July 2018
<i>Macroscelisia japona</i>	Female	5.8	11.3	13.1	<i>Li. lucidum</i>	Saki (alt. 0 m) on Nakanoshima	12:00 on 9 July 2018
<i>Synanthedon unocingulata</i>	Male	6.9	10.8	14.0	<i>K. septemlobus</i>	Uragou (alt. 100 m) on Nishinoshima	13:30 on 10 July 2018

Table 3. Clearwing moths in the Oki Islands.

Species	Island	References
<i>Entrichella constricta</i>	Nishinoshima	Hayashi <i>et al.</i> , 2013
<i>Melittia sangaica</i>	Nishinoshima	Hayashi <i>et al.</i> , 2012
<i>Macroscelisia japona</i>	Dōgo, Nishinoshima	Kadowaki and Kishida, 1977; Hayashi <i>et al.</i> , 2012
<i>Nokona regalis</i>	Nakanoshima	Hayashi <i>et al.</i> , 2013
<i>Nokona pernix</i>	Nishinoshima	Mishima and Ohama, 2009; Hayashi <i>et al.</i> , 2012
<i>Synanthedon tenuis</i>	Nishinoshima	Hayashi <i>et al.</i> , 2012
<i>Glossospehia romanovi</i>	Nishinoshima, Nakanoshima	This study
<i>Synanthedon unocingulata</i>	Nishinoshima	This study

Previous studies have reported the flower-visiting behaviour of at least 17 clearwing moth species (Table 4; Arita and Nakano, 1995; Arita and Ikeda, 2000; Ikenoue, 2005). *Macroscelisia japona* has been previously reported to visit the flowers of at least five plant species (Arita and Ikeda, 2000), although it has not been recorded to visit *Li. lucidum* flowers. The flower-visiting behaviour of *G. romanovi* and *Sy. unocingulata* has remained undocumented, although the photographs of *G. romanovi* visiting the flowers of *Cayratia japonica* (Thunb.) Gagnep. (Vitaceae) could be viewed on the internet. To our knowledge, this is the first report of the flower-visiting behaviour of *G. romanovi* and *Sy. unocingulata*. Previous reports and our results suggest that clearwing moths visit small and/or shallow flowers, from which nectar is easily accessed (Table 4). Therefore, investigating the visitors of small, shallow flowers in summer contributes to the knowledge of the flower-visiting behaviour of other clearwing moth species.

The adult *G. romanovi* is thought to mimic *Vespa* hornets (Vespidae: Vespinae) because its shape, colour and behaviour (buzz) are similar to those of the hornets (Arita and Ikeda, 2000). *Macroscelisia japona* and *Sy. unocingulata* may also mimic potter wasps (Vespidae: Eumeninae). Hornets and potter wasps were frequently

observed to visit *Li. lucidum* and *K. septemlobus* flowers that were also visited by clearwing moths, suggesting that potential predators such as birds avoid *G. romanovi*, *Ma. japona*, and *Sy. unocingulata* on these flowers. A comparison of flower-visiting behaviour between vespids and clearwing moths is required to elucidate how clearwing moths mimic these model insects.

Acknowledgments

We thank Dr Hideshi Naka (Tottori University) for identifying the clearwing moths. We also thank anonymous reviewers for helpful comments on this manuscript. This study was supported by a grant from the Hoshizaki Green Foundation.

References

- Arita, Y., 2013. Sesiidae. In Hirowatari, T., Y. Nasu, Y. Sakamaki and Y. Kishida (eds), Standard of Moths in Japan III. pp. 332-341, figs 61-65. Gakken Education Publishing, Tokyo. (in Japanese)
- Arita, Y. and M. Ikeda, 2000. Sesiidae of Japan. 203pp. Mushi-sha, Tokyo, Japan. (in Japanese)
- Arita, Y. and H. Nakano, 1995. Records of flower-visiting clearwing moths (Lepidoptera, Sesiidae) in Amami-Oshima Island. *Tyō to Ga* 45: 242-244. (in Japanese with English summary)
- Hayashi, M., T. Matsuda, H. Kadowaki, H. Fukaya and Y. Chikami, 2012. Research on insect distribution of Oki Islands, Shimane

Table 4. Flower-visiting clearwing moths in Japan.

Clearwing moth species	Flowering plant species visited by moths	References
<i>Entrichella constricta</i>	<i>Cayratia japonica</i>	Arita and Ikeda, 2000
<i>Entrichella esakii</i>	<i>Tetradium glabrifolium</i>	Arita and Nakano, 1995
<i>Paranthrenopsis editha</i>	<i>Erigeron annuus</i>	Arita and Ikeda, 2000
<i>Milisipepsis takizawai</i>	<i>Clethra barbinervis</i> , <i>Astilbe microphylla</i>	Arita and Ikeda, 2000
<i>Melittia inouei</i>	<i>Te. glabrifolium</i> , <i>Ca. japonica</i> , <i>Ligustrum lucidum</i>	Arita and Nakano, 1995; Arita and Ikeda, 2000; Ikenoue, 2005
<i>Melittia sangaica</i>	<i>Ca. japonica</i> , <i>Sambucus chinensis</i>	Arita and Ikeda, 2000
<i>Macroscelesia longipes</i>	<i>Torilis japonica</i> , <i>Persicaria lapathifolia</i> , <i>Pe. senticosa</i>	Arita and Ikeda, 2000
<i>Macroscelesia japona</i>	<i>Er. annuus</i> , <i>Lysimachia clethroides</i> , <i>Ca. japonica</i> , <i>Te. glabrifolium</i> , <i>Angelica pubescens</i> , <i>Li. lucidum</i>	Arita and Nakano, 1995; Arita and Ikeda, 2000; this study
<i>Nokona pernix</i>	<i>Er. annuus</i> , <i>Ca. japonica</i> , <i>Li. lucidum</i>	Arita and Ikeda, 2000; Ikenoue, 2005
<i>Glossospehia contaminata</i>	<i>Ca. japonica</i>	Arita and Ikeda, 2000
<i>Synanthedon yanoi</i>	<i>Hydrangea paniculata</i> , <i>Aruncus dioicus</i> , <i>Cl. barbinervis</i>	Arita and Ikeda, 2000
<i>Sy. scoliaeformis</i>	<i>An. pubescens</i>	Arita and Ikeda, 2000
<i>Sy. hector</i>	<i>Hy. paniculata</i> , <i>Cl. barbinervis</i> , <i>As. microphylla</i>	Arita and Ikeda, 2000
<i>Sy. formicaeformis</i>	<i>Ar. dioicus</i> , <i>Hy. paniculata</i> , <i>Sorbaria sorbifolia</i> , <i>As. microphylla</i>	Arita and Ikeda, 2000
<i>Sy. fukuzumii</i>	<i>Er. annuus</i>	Arita and Ikeda, 2000
<i>Sy. tenuis</i>	<i>Hy. paniculata</i> , <i>Cl. barbinervis</i>	Arita and Ikeda, 2000
<i>Sy. multitarus</i>	<i>Hy. paniculata</i> , <i>Er. annuus</i> , <i>An. pubescens</i> , <i>As. microphylla</i>	Arita and Ikeda, 2000
<i>Glossospehia romanovi</i>	<i>Kalopanax septemlobus</i> , <i>Li. lucidum</i>	This study
<i>Sy. unocingulata</i>	<i>K. septemlobus</i>	This study

- Prefecture, Japan, Part 2. *Bull. Hoshizaki Green Found.* **15** : 287-297. (in Japanese with English summary)
- Hayashi, M., H. Kadowaki, T. Matsuda, H. Fukaya and Y. Chikami, 2013. Research on insect distribution of Oki Islands, Shimane Prefecture, Japan, Part 3. *Bull. Hoshizaki Green Found.* **8** : 1-73. (in Japanese with English summary)
- Ikenoue, T., 2005. Records of moths attracted to flowers in the eastern part of Yamaguchi Prefecture. Supplement I. *Yugato* **181** : 89-105. (in Japanese)
- Jinbo, U., 2016. List-MJ: A checklist of Japanese moths ver 2. <http://listmj.mothprog.com/>. [access 28 July 2018].
- Kadowaki, H. and Y. Kishida, 1977. Moths of the Oki Islands II. *Jpn. Heterocerist's J.* **91** : 506-513. (in Japanese)
- Kunte, K., 2007. Allometry and functional constraints on proboscis lengths in butterflies. *Func. Ecol.* **21** : 982-987.
- Mishima, H. and S. Ohama, 2009. Moths of the Oki Islands. *Sukashiba* **57** : 45-104. (in Japanese)
- Oki Islands Geopark Promotion Committee, 2013. Application Dossier for Nomination to the Global Geoparks Network: Oki Islands Geopark. 49 pp. Oki Islands Geopark Promotion Committee, Okinoshima, Japan.
- Scoble, M.J., 1992. The Lepidoptera. Form, function and diversity. 404pp. Oxford Univ. Press. Oxford, UK.
- Skowron Volponi, M.A., D.J. McLean, P. Volponi and R. Dudley, 2018. Moving like a model: mimicry of hymenopteran flight trajectories by clearwing moths of Southeast Asian rainforests. *Biol. Lett.* **14** : 20180152.
- Sugiura, S. and M. Hayashi, 2018. Functional compensation by insular scavengers: the relative contributions of vertebrates and invertebrates vary among islands. *Ecography* **41** : 1173-1183.
- Tiple, A.D., A.M. Khurad and R.L. H. Dennis, 2009. Adult butterfly

feeding-nectar flower associations: constraints of taxonomic affiliation, butterfly, and nectar flower morphology. *J. Nat. Hist.* **43** : 855-884.

摘 要

隠岐諸島におけるスカシバ類の訪花記録 (杉浦真治・阪上 洸多・林 成多)

スカシバ類成虫の形態や色彩、行動はスズメバチ類やアシナガバチ類、ドロバチ類に擬態していると考えられている。スカシバ類成虫は昼行性だが、他の昼行性の鱗翅類（チョウ類）と比べて訪花記録は少ない。隠岐諸島中ノ島と西ノ島において、2018年7月の梅雨明け直後にスカシバガ科3種の訪花行動を観察した。中ノ島の集落で植栽されたトウネズミモチでクビアカスカシバ雄とモモトスカシバ雌の訪花を、西ノ島の放牧地に自生するハリギリでクビアカスカシバ雌とキオビコスカシバ雄の訪花を観察した。同時に、擬態のモデルと考えられているスズメバチ類やドロバチ類なども盛んに訪花しているのが観察された。モモトスカシバはこれまでも多様な植物種で訪花が記録されてきたが、クビアカスカシバとキオビコスカシバについては著者らが知る限り初めての訪花記録となる。また、隠岐諸島からはこれまでモモトスカシバを含むスカシバガ科6種が記録されているが、クビアカスカシバとキオビコスカシバは隠岐諸島から初めての記録となる。

(Received September 16, 2018. Accepted January 13, 2019)